RELATIONSHIPS BETWEEN SIZE OF SCHOOLS AND SCHOOL DISTRICTS AND THE COST OF EDUCATION

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ABSTRACT

More than 30 studies of size of economies in the production of local education services are reviewed in terms of their theoretical basis, methodological approach, data, results, and possible applications. The consistency of the reported results suggests with certain qualifications that increased size of elementary and secondary schools will permit some limited economies. Economies will also result when more students are administered by the same school district. Care must be taken in applying these results because the degree of savings also depends on other factors, such as quality of education provided and transportation costs.

Keywords: Economies of size, Economies of scale, Local government, Community development, Communities, Rural development, Cost functions, Costs, Education, Schools.

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SUMMARY

More than 30 studies have attempted to measure the relationship between size of schools or school districts and the cost of education. Our conclusion, based on this research, is that there are size-economies for elementary education, secondary education, and school district administration. Elementary education may experience economies for relatively small student populations (perhaps 300 to 600 pupils), secondary education may experience economies into the 1,400 to 1,800 pupil range, and school district administration will exhibit economies over a greater pupil range.

Application of these findings to most cost questions must be considered carefully and should be on an individual case basis because cost factors other than size are often changed by the circumstances. Consolidation, for example, will likely change the quality of education, breadth of curriculum, and transportation requirements. Conclusions regarding the efficacy of consolidation will depend on decisions related to these other cost factors as well as size.

Relationships Between Size of Schools and School Districts and the Cost of Education

William F. Fox

INTRODUCTION

This report reviews the more than 30 studies which have attempted to measure the importance of size-economies (a system whereby one obtains the optimum use from funds available) in the provision of education, with emphasis on the theoretical, methodological, and empirical basis of each.

The purposes are to: (1) determine the degree to which size-economies in education exist; (2) consider the potential applications of size-economies research; (3) evaluate the theoretical basis of size-economies literature; (4) examine the appropriateness of the data sets which have been utilized; and (5) analyze the methodology applied in size-economies research.

This report specifically reviews research on size-economies in education, although the findings of purposes (2) through (5) are in many ways applicable to other research on size-economies in local government.

The findings of this report are useful to technical staffs advising local school officials, State education authorities, and education policymakers at the national level, as well as researchers, academicians, and others interested in the costs of providing local education. The paper is technical because the unifying theme is conceptual and the results are dependent on a full development of the approach to examining the relationship between size of schools and costs of education. Thus, though the results are of widespread interest, the body of the monograph is oriented toward researchers and others interested in justification of how the results are obtained. Substantial apparent conflict in the empirical results has caused a need to draw the results into one consistent package.

Education is considered a primary factor in personal development and economic and social well-being. This is considered true both for the Nation and within any given region of the United States (12). Education, through school facilities and organization, has an even broader role in the quality of life by serving as a center for many social services and functions, particularly in rural areas (46). USDA has a policy coordination role as a result of the Rural Development Act of 1972 and over-

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2/ Underscored numbers in parentheses refer to items in Literature Cited at the end of this report.

riding interest in improving the quality of life in rural places. This leads to an important interest of USDA in the provision of adequate local education at reasonable cost.

Education's role in economic and personal development has created substantial local government interest in achieving economy and efficiency in the provision of quality education. For the most part, policymakers believed that only large schools and school systems could offer greater quality and breadth of curriculum at lower costs, and they viewed smaller schools as inefficient.

For example, eminent educator James B. Conant concluded in 1967 that "an excellent comprehensive high school can be developed in any school district provided the high school enrolls at least 750 students and sufficient funds are available. (6)" So, smaller towns and less densely populated areas were felt to be the least able to achieve the school size policymakers considered necessary to provide quality education at a reasonable cost, and school consolidation was seen as the one way to achieve this goal.

This belief in consolidation has resulted in an astounding decrease in the number of U.S. schools and school systems. There were 128,000 public school districts and 262,000 public elementary and secondary schools in 1930 but fewer than 17,000 school districts and less than 90,000 elementary and secondary schools in 1975 (13, 47). Total public school enrollment during this period nearly doubled to total more than 45 million (13).

The consolidation movement in rural areas can best be demonstrated by the reduction in one-teacher schools. One-teacher elementary schools declined from 149,000 to just over 1,000 between 1930 and 1975. Several factors, including population redistribution, contributed to these startling changes, but the quest for economy and efficiency through the development of larger schools and districts was a major determinant.

Economists and other researchers began intensive investigation of the relationship between cost of education and size of schools in the late fifties, after the consolidation movement was well underway. The controversy over whether consolidation resulted in cost savings was the key stimulant to development of the size-economies research. The apparent lack of consistent results has led to studies which still continue.

Study of size-economies remains timely and vital for rural areas because the consolidation wave has greatly influenced rural America's educational structure. However, a new consolidation thrust is likely to develop in the face of population redistribution and a shrinking student population.

THEORETICAL BASIS FOR SIZE-ECONOMIES RESEARCH: THE MODEL

Proper analysis of size-economies must begin from a solid theoretical base. Unfortunately, most research has been empirically, rather than theoretically, oriented. Failure to develop a theoretical base to adequately describe the behavioral relationships within which the local government operates may lead to incorrect inferences regarding whether size-economies do or do not exist.

Often, the economic theory which serves as a basis for this research is not explicitly presented in the studies, although most size-economies research appears to have its theoretical roots in the theory of the firm. But, the analogy between the firm as producer and the local government as producer has some weaknesses. The most notable difficulty is that local governments (to the extent they represent the people) are both producers and consumers of services, and the supply or cost behavior of the government must therefore be separated from its demand responses in any study of government provision of services.

Development of Model

The implicit theoretical underpinnings of the studies done can be most easily evaluated by contrasting the empirical models used with the appropriate estimation technique derived from an explicit model. This section develops a local government behavioral model to establish a system within which the cost-output relationship for education can be estimated. The local government is seen, not simply as an institution, but as an active participant involved jointly with residents in determining service levels.

The prime motivational goal for size-economies research is efficiency. Thus, an optimization model is adopted because it represents an approach in which service levels are set in order to maximize well-being and input usage is determined to minimize costs, given the constraints on local government behavior.

The model developed here describes the relationship between the choice of education service levels, the unit cost of providing the service level, and the optimal choice of inputs for producing the education. 3/ These relationships are presented in a demand/supply context wherein the local citizenry communicates its demand for services to the local government. Cost minimizing criteria, balanced with bureaucratic constaints, provide the basis for setting the local governments' input usage.

Input usage and prices are combined with the production function to yield the unit cost of production for the desired output level. 4/ So, the model permits determination of optimal service levels, the inputs to be used in achieving the service levels, and the cost of the services.

Demand

The first step in developing a local government behavioral model is consideration of the demand for government services. Demand, in an optimization model, is evaluated by accepting a specific utility function and then maximizing it subject to the constraints to be faced by decisionmakers. 5/ The model's utility function is determined by the group controlling the setting of local government service levels, whether this is all citizens, a subset of citizens, policymakers, or some other group.

The utility function adopted for this report presumes that voters have the ultimate control over service levels, given the production and tax costs. The economic literature appears to be dominated by variations on two explanations of how individual

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3/ Education service levels refer to the mix of academic training, vocational training, physical education, social skills, and others which compose the desired output of the education system. Difficulties in quantifying the outputs of education are discussed on pages 15-16.

4/ Input usage describes the choice of the types and quantities of resources used in producing the educational outputs. Teachers, books, audio visual equipment, classrooms, and gymnasiums are examples of inputs which are chosen in varying quantities.

5/ A utility function is a conceptual device for translating consumption of goods and services by a group or individual into levels of well-being.

voters' preferences for local government services are translated into actual production.

One is the median voter approach, in which the demand for services is conveyed to government officials by a decisive subset of local citizens. Continuous interactions between the citizens leads to decisions on the optimal level of output. This explanation is appropriate when local governments can be assumed to operate in a Tiebout world--one in which people choose their location by considering a large number of alternative packages of government service levels and tax prices (49).

The dominant party model is the other approach. Within this potential explanation of utility translation, a single group wins control of decisionmaking through public elections. This group then sets service and expenditure levels according to its own utility function, which is influenced by the group's desire to retain power in the next election.

The median voter model is used here and is appropriate, as most size-economies studies have centered on small-to-moderate-size cities. The Tiebout world can be most closely approximated by the use of the median voter model (21).

Assume, as shown in equation (1), a utility function dependent upon the level of government services (education) consumed by the median voter (G*) and the amount of private goods (Q_j, j = private goods) available to the median or representative voter. The level of education consumed by the median voter (G*) must be distinguished from physical production of services (G). This distinction is important because producers are likely to see education in terms of teachers and books, while residents envision education as high test scores, babysitting, and improved job prospects.

In equation (2), D is a vector of service characteristics which converts production units (G) to consumption units (G*) (31). Population (N) is included in defining G* in order to account for the degree to which local services are pure "Samuelsonian" public goods. 6/ If $\alpha = 0$ the local service is purely public, but if $\alpha > 0$ some crowding out occurs in the consumption of the local services.

(1) $U = (G^*, Q_j)$

(2) $G^* = \frac{G}{D} \cdot N - \alpha$

Optimal provision of G* is determined by maximizing equation (1) subject to the budget constraint presented in equation (3). The budget constraint shows that total spending for public services ($P_G G$) plus total spending for private goods ($\sum_j P_{Q_j} Q_j$) minus business property taxes paid at a uniform rate (t) on industrial and commercial property (I) minus intergovernmental transfers (z) must equal residential income (y), where P stands for the prices of the goods. The income constraint adopted here assumes that intergovernmental tranfers are exogenous and industrial location is unresponsive to tax rate changes.

(3) $P_G G + \sum_j P_{Q_j} Q_j - tI - Z - y = 0$

6/ A pure "Samuelsonian" public good exhibits the characteristics that one person's consumption of the good does not prevent another person from consuming the same good (for example, national defense) and that no person can be excluded from consuming the good.

First order conditions, which are derived by differentiating equation (1) subject to the budget constraint with respect to the choice variables G and Q_j, can be solved for the demand equation for education outputs and all j demand equations for private goods. 7/ Demand equations for local services are shown to be a function of the vector of service conditions, population, price of education, prices of all goods, amount of nonresidential property, intergovernmental grants, and income (equation (4)). 8/

(4) $G = G(D,N,P_G,P_{Q1}...P_{Qm},I,z,y)$

Supply

A production function relates inputs to outputs and a cost function shows the cost of providing various output levels. Applications of the duality theory to production and costs have shown that under certain maintained conditions a particular production function implies a given cost function and vice versa. 9/ Therefore, the supply aspects of the system can be modeled either in terms of production or cost functions (3). A cost function is modeled here as most size-economies studies have adopted this approach.

The production function (equation (5)) relates the various inputs to the production of education. For simplicity, assume that educational output is a function of capital (K), labor (L), pupil inputs (M), service conditions (S), and technology (T). The local government should attempt to minimize the cost of producing each level of output so the average cost curve (equation (7)) can be derived by maximizing the production function subject to the cost constraint (equation (6)). P_L and P_k are the price of labor and the price of capital, respectively.

(5) $G = f\ (K,L,M,S,T)$

(6) $P_G G = P_L L + P_K K$

(7) $P_G = P_G(K,L,P_K,P_L,M,G,S,T)$

Development of demand and average cost relationships is not sufficient, however, to provide a completely identified system. The individuals making production decisions are also determining the appropriate use of capital and labor. An additional equation is necessary for each school input in order to account for the decision rule involved in selecting the appropriate use of inputs.

7/ G and G* are definitionally related by equation (2) so demand can be quantified by either. Legitimate arguments can be made for evaluating demand in terms of either measure of output. However, as size-economies is a study of efficiency in production, we have chosen to measure demand in terms of producer's output.

8/ If this study were focusing on demand for local government services and, in particular, the price elasticity of demand, the tax share should be included as the price. However, for supply-side analysis of size-economies, average cost is a more useful measure of price. Of course, when average cost measures price, the demand equation must hold constant nonresident revenue sources.

9/ Duality theory refers to the linear-programming concept that if a finite maximum exists for a problem (for example, of profit maximization), a finite minimum must also exist for a converse restatement of the problem (for example, of cost minimization).

The decision rule for use of inputs will probably relate the desired level of inputs to the traditional cost minimization or profit maximization factors--level of output to be produced, price of inputs, service conditions, and technology applied. There may, however, be certain bureaucratic constraints which prevent governments from choosing inputs that operate at minimum costs (36).

Two typical hypotheses about bureaucratic behavior are: (1) bureaucrats seek to maximize the agency budget rather than minimizing costs; and (2) bureaucrats seek to operate with an above-minimum-cost staff (37). The first hypothesis can be at least partially taken into account by constraining this year's budget to, at minimum, equal last year's budget. Inefficient use of staff can be considered in a similar manner by making last year's staff a minimum for this year. Equations (8) and (9) show the bureaucratic constraints and equations (10) and (11) represent the purchase of inputs.

(8) $P_{Gt} G_t \geq P_{Gt-1} G_{t-1}$

(9) $L_t \geq L_{t-1}$

(10) $L_t = L_t \, (G_t, L_{t-1}, P_{G_{t-1}} G_{t-1}, P_{L_t}, P_{K_t}, M, S, T)$

(11) $K_t = K_t \, (G_t, P_{G_{t-1}} G_{t-1}, P_{K_t}, P_{L_t}, M, S, T)$

Equations (4), (7), (10), and (11) provide a system of four equations with four unknowns--educational output, per unit education costs, labor inputs, and capital inputs. Interactions between the variables require that the system be estimated using a simultaneous equations estimation technique, such as two- or three-stage least squares. Solution of this system of equations should provide unbiased and consistent estimators of the regression coefficients. Then the output coefficient in equation (7) can be examined to determine whether size-economies exist.

CLASSIFICATION OF EDUCATION LITERATURE

Size-economies research can be classified into five groups by comparing the research to the theoretical framework already developed (see table).

Ad Hoc Expenditure Functions

The first comments on size-economies were based on ad hoc expenditure studies. There, the multiple equation system already discussed was reduced to one equation with average cost as the dependent variable. Typically, average expenditure was used as a proxy for average cost and population served for output. Ordinary least-squares regression was used to test size-economies. A number of expenditure studies were empirically reviewed by Denzau in 1975 (9).

However, research of this type provides little information about the cost of providing services or the relationship between the costs and the scale of service provision. Solving the demand and average cost equations ((4) and (7)) to one equation eliminates either output or average cost, from a theoretical perspective. Therefore, without additional theoretical restrictions on the system, expenditure studies of this type cannot be identified for quantitative analysis.

Size-economies, as already discussed, refer to the relationship between average costs and level of services provided; it is a supply-side phenomenon. The expenditure equation approach, however, does not separate supply and demand effects. Instead, the regression coefficients of the expenditure equation are a function of structural

Summary of education size-economies research

Study	Theoretical basis	Measure of costs	Results
School-level studies:			
Cohn (5)	1/ C	School costs.	U-shaped average cost curve with a minimum at 1,675 pupils.
Hind (17)	1/ C	Separates administrative, instructional, and maintenance costs.	Maintenance displays economies throughout. Other areas demonstrated a U-shaped average cost curve with a minimum at 600 pupils.
Johnson (24)	1/ C	Current expenditures.	U-shaped average cost curve with a minimum at 1,426 pupils.
Katzman (27)	1/ 4/ C,P	Both current and instructional costs.	U-shaped average cost curve with a minimum between 1,400 and 1,800 pupils.
Katzman (26)	1/ 4/ C,P	Both current and instructional costs.	Finds diseconomies to instructional costs. Finds economies for reading and diseconomies for Latin education production.
Kiesling (28)	4/ P	Current expenditures.	Constant returns to scale are obtained.
King and Wall (30)	Simulation	Total costs less administration.	School gymnasiums are significant contributors to size-economies.
Michelson (33)	4/ P		Size is positively associated with pupil-teacher ratios but may harm output.
Michelson, Gray, Millstein, and Polly (34)	1/ C	Teacher expenditures.	Finds some evidence of size economies.
Osburn and Goishi (38)	1/ C	Current and capital	Minimum average costs for vocational schools at 488 pupils.
Riew (42)	1/ C	School operating costs.	U-shaped average cost curve with a minimum at 1,675 pupils.

See footnotes at end of table.

Continued--

Summary of education size-economies research--Continued

Study	Theoretical basis	Measure of costs	Results
School-level studies:			
Rosenberg (43)	1/ C	Current expenditures.	Tends to find U-shaped average cost curve.
Wright and Pine (55)	1/ C	Administration, instruction, and maintenance.	Schools under 100 pupils have higher costs. Some evidence of additional economies.
District-level studies:			
Brown (2)	3/ I	Instructional expenditure.	Slight economies for cities over 10,000 population which are focal points for economic activity.
Dawson (7)	1/ C	Total costs.	Economies of size or constant returns for districts with single schools. Some diseconomies across all districts.
Debertin (8)	1/ C	Instructional costs.	Economies of size in North Dakota but not Indiana.
Denzau (9)	3/ E	Current expenditures.	No relationship between expenditures and district size.
Hanson (15)	1/ C	Current expenditures.	U-shaped average cost with a minimum at about 50,000 pupils.
Hettich (16)	1/ C	Current expenditures.	Slight economies for elementary schools to 300 pupils and diseconomies above. Economies for secondary schools to 600 pupils.
Hirsch (18)	1/ C	Current expenditures plus debt service.	No significant economies are found.
Hirsch (19)	1/ C	Administration costs.	U-shaped average cost curve with a minimum at 44,000 pupils.

See footnotes at end of table.

Continued--

Summary of education size-economies research--Continued

Study	Theoretical basis	Measure of costs	Results
District-level studies:			
Holland and Baritelle (20)	Simulation	Total costs.	Could save approximately 1 percent of costs through consolidation.
Kiesling (29)	4/ P	Current expenditures.	Constant returns to scale are found.
Niskanen and Levy (36)	4/ P	Current expenditures.	Some evidence of diseconomies is found.
Osburn (39)	1/ C	Current expenditures.	U-shaped average cost curve with a minimum at 2,244 pupils.
Sabulao and Hickrod (44)	1/ C	Current expenditures.	U-shaped average cost curve is found.
St. Louis and McNamara (48)	1/ C	Total expenditures.	U-shaped average cost curve with a minimum at 51,000 pupils.
Shapiro (45)	1/ C	Total expenditures net of debt service and contributions to building and loan fund.	Finds size-economies.
Wales (51)	1/ C	Separates salaries, operating costs, and administrative costs.	Size-economies are indicated for each cost component. Examines economies at the school level for teacher costs.
White and Tweeten (54)	1/ 4/ C,P	Administration, maintenance, and buildings cost; equipment and transportation are analyzed separately.	U-shaped average cost curve with shape dependent on the desired quality of the program.
White and Tweeten (53)	1/ C	Administration, capital instruction, maintenance, and transportation are analyzed separately.	Including transportation costs finds U-shaped average cost with a minimum at 675 pupils.

See footnotes at end of table.

Continued--

Summary of education size-economies research--Continued

Study	Theoretical basis	Measure of costs	Results
County-level studies:			
Perkinson (40)	--	Total costs.	Little association between per capita expenditure and population size.
Ricker and Tyner (41)	1/ C	Inschool costs excluding transportation and capital improvements.	Size-economies are found at a decreasing rate.
State-level studies:			
Hambor, Phillips, and Votey (14)	3/ I	Teacher salaries.	Slight, though insignificant, size-economies.
Welch (52)	Examines returns to education.	Total current expenditures.	Size-economies are found.

-- Not applicable.

1/ C = cost approach is used.

2/ E = expenditure determinants approach is used.

3/ I = identified model is adopted.

4/ P = production function approach is used.

coefficients from both the demand and supply equations. The shortcomings of this approach make it unusable for size-economies research; therefore, the numerous expenditure studies are not analyzed here.

Cost Functions

The most common approach to testing for size-economies concentrates on single-equation estimates of average cost functions (equation (7)). Twenty-four of the 35 studies reviewed are cost studies with examples being the work of Cohn, Katzman, Riew, and White and Tweeten (4, 27, 42, 53). Researchers applying the cost function approach realized that only supply factors should enter into the equation used to analyze size-economies 10/. But, instead of identifying a separate demand equation, these studies generally ignore the demand side of the market. Also, the simultaneous choice of inputs and desired outputs by school boards is overlooked. These omissions create a simultaneous bias for the cost studies.

Production Functions

Supply, as noted, may be analyzed either in terms of an average cost function or a production function. A production function has the same form as an average cost function except that input prices do not enter the equation, and it is more difficult to implement and has been used only by Kiesling, Michelson, and Katzman (26, 27, 28, 29, 33, 34).

There are inherent weaknesses in using the production function approach to test for size-economies in education. Production function is the rigidly defined relationship between factors of production (inputs) and units of outputs. Because of difficulties in accounting for technology, managerial skill, and human capital, input/output relationships are difficult to empirically describe for production of physical outputs in private markets and have frequently been handled improperly (24). Production functions are especially difficult to use for services, such as education, because the relationship between inputs and outputs has not been clearly defined in conceptual terms.

Conceptual and empirical difficulties in quantifying potential size-economies have also arisen because researchers have typically examined the relationship between quantity and quality (for example, number of students and test scores), not between quantity and scale of operations. Lack of information on size of production plant has made empirical measures of scale hard to find. Finally, estimation of a production function requires good proxies for inputs and outputs, something difficult to obtain.

Production function estimates also fail to account for the simultaneous choice of inputs and outputs by the school district. Furthermore, the criteria used for choosing input usage must be included in the analysis, as noted in the theoretical section. This usually has not been done in research using the production function approach; therefore, production function estimates also suffer from a simultaneous equation bias.

10/ Occasionally a demand-related variable was included in a cost curve equation. Nonetheless, we classified the model as a cost curve when the intent was clearly to estimate a cost curve.

Derived Expenditure Equations

Derived expenditure equations provided some of the first conceptual innovations to the study of local government behavior because they attempted to develop an estimatable model which considers both supply and demand (1). However, this research, though having a strong theoretical basis, was unable to separately identify the supply and demand elements. Those doing this type of research usually assume size-economies to be unimportant, allowing the empirical results to be interpreted as demand estimates. Therefore, this body of literature is not oriented towards size-economies research and is excluded from further consideration here.

Identified Models

Each of the already mentioned models has theoretical or econometric problems in its general approach. Expenditure studies fail to isolate demand and supply elements. The supply side must be considered and analyzed separately when obtaining information on the relationship between costs of producing education and size of the production.

Single-equation estimation techniques for cost studies are usually used to relate supply costs to the level of output. However, output is determined within a supply and demand framework and cost studies typically ignore the demand element. Unbiased estimates of the regression coefficients cannot be estimated in this case because output would be correlated with the error term.

Production function techniques also may suffer from simultaneous equations bias. This results because the level of input usage is usually determined by the individuals responsible for setting production levels and the input combinations are not necessarily cost minimizing.

Identified models represent the final approach, and this category includes research that seeks to estimate a system, such as the four-equation theoretical model already discussed. Only two studies are reviewed which seek to develop and estimate a theoretically sound model that isolates demand and supply (2, 14). Neither study is completely identified but each represents an important step in developing sound theoretical analysis. Identified models are preferable to any of the other four approaches because with proper estimation techniques they lead to unbiased coefficient estimation wherein the interactions between demand, supply, and input choices are taken into account.

EMPIRICAL AND METHODOLOGICAL ISSUES

Knowledge of the issues pertaining to estimation, data, and methodology is needed because these issues pertain to the studies examined here. The unit of analysis is considered first, then output and input measures, and other data issues.

Unit of Analysis

The two most popular units of analysis in size-economies research are the school and the school district. Eighteen of the studies analyzed used the school district as the unit of analysis and 13 used the school. Also, two studies used counties and two used States (see table).

The appropriate unit of analysis depends on the questions being asked and on the desired application of the results. Potential economies from spreading district administration expenses over more students must be analyzed at the school district level. But, such a line of inquiry must also consider cost interactions between the number of schools and the number of students. Administrative costs are different when more students are educated in the same buildings than when more students are educated by adding more occupied buildings to the school district.

Presumably, administrative costs rise with the number of schools when student populations per district are held constant. The economies from administering more students will probably depend on how many schools are used to house them, yet the appropriate unit of analysis would be the entire district.

Correspondingly, school-level costs would be most appropriately evaluated with school-level data. That is, the costs and outputs of each building should be evaluated separately in order to examine the economies from shared buildings and equipment and from larger pupil-teacher ratios. However, because of different equipment needs and course offerings, elementary and secondary schools must be considered in separate analyses. One should seek to examine all costs associated with the individual school unit, including capital, labor, and administrative costs, for research related to school-level costs.

Data limitations frequently require researchers to examine school-level costs using aggregate district-level expenditures and pupils. Thus, several factors must be considered for these results to be meaningful.

First, elementary education and secondary education are characterized by different cost functions and different output vectors. Therefore, productive evaluation of school costs using district-level data becomes more complex because districts are composed of various combinations of elementary and secondary schools. The multiproduct nature of the school district must be taken into account.

Second, more than one school requires consideration of the multischool characteristics of production as most economies are probably associated with school size. Finally, from a data perspective, good surrogates for outputs and inputs in the production process are more difficult to develop for the school district as a whole than for a single school.

Several researchers have sought to account for the different cost conditions associated with elementary and secondary schools. Hirsch, in 1960, used the percentage of students in secondary schools as an output index, but this method does not allow for the different marginal costs entailed in elementary and secondary schools (18).

The method also failed to consider the number of schools producing the education and examined costs along an output ray where the proportion of elementary and secondary students is held constant. 11/ This may lead to the economies from one level of education being offset by diseconomies from another level of education.

The approach used by Hettich in 1968 used separate scale measures for the average number of students in each district enrolled in elementary and secondary schools (16). Here, the percentage of pupils enrolled in secondary schools was included as an output proxy. Several assumptions are implicit in the scale proxies. The districts are assumed to choose optimal size plants so that enrollment measures school capacity and the schools are assumed to be equally subscribed. School districts are assumed to divide students at each level into like size units; very different costs

11/ An output ray describes every level of education output for which the output components are held proportionately constant.

could be associated with two districts which have the same number of pupils if one district has a large and a small school and the other district has two schools of the same size.

This approach, given the implicit assumptions, may be appropriate for analyzing school costs, though the use of district costs and the unavailability of a good output index will probably bias the estimated coefficients. The Hettich results are not useful, however, for many questions related to consolidation (16). The study, for example, does not examine the impact on cost of increasing the number of schools, nor does it examine whether there are economies to producing elementary and secondary education under the same administrative unit.

Other district level studies have avoided the complexities introduced by the combining of a district's secondary and elementary schools by examining only the secondary schools (7, 29). However, elementary-level expenditures may still be mixed with secondary expenditures in the cost proxy.

The production relationship itself may be biased because elementary education is not only an output of the educational process, but it is an input to secondary education. The interrelationship between these stages of production must be modeled. Also, examining the secondary schools in a district does not overcome the problem of accounting for multiple schools producing education. Dawson, in addition to his results for all districts, estimated cost functions using districts with only one high school (7). He found economies or constant returns when districts with one school were anlayzed, but the average cost curve had an inverted "v" or lazy "s" shape for all districts. Clearly, the cost relationships for multischool districts appear to be distorted.

Other studies using district level data do not explicitly examine the multiproduct nature of elementary and secondary education. They also fail to account for those situations in which education is produced in several different schools. Therefore, the conclusions regarding school costs derived from district level studies must be viewed cautiously. The district is a more appropriate unit of analysis for examining economies from administering more students or more schools, although the interaction between school costs and district administrative costs should also be examined at the district level.

Most research relying on the district as the unit of analysis uses current or instructional expenditures as the cost measure and so seeks to examine school costs. The district, as noted, is the appropriate unit of analysis for general administrative costs. Only four of the district-level studies reviewed here separately analyze administrative costs, although some researchers examining administrative expenses may have inappropriately included school-level administration costs (19, 51, 53, 54).

Each study of administrative expenses finds economies associated with district size. Not surprisingly, research which examines current or instructional costs across districts has had mixed results because administrative costs are either included with all other costs or are omitted and because any economies associated with the number of pupils or school size could be combined, leading to a diluted result.

Further disaggregation of the analysis unit into programs or curricula within a school has also been suggested (5, 7). Dawson disaggregated costs by academic program within school districts in 1972 and different cost relationships were found for each program (6).

Analysis, to the extent that economies differ between types of programs, as was found by Dawson, is still needed to determine the viability of offering different curricula within the same school as well as the savings associated with increasing the size of the school. Economies resulting from an increase in the size of a school will then depend on the curriculum mix associated with the increase if the economies differ by program.

County and State data, although infrequently used to study education costs, represent larger political units than those usually responsible for providing education, and research based on them would represent aggregations of a variety of actual service units. Thus, it appears that little could be learned about size-economies from such aggregated data.

Output Measures

Two components comprise educational output: quantity and quality. Total output can be obtained by multiplying the quantity of output units times the quality per unit of output. Two problems arise in defining quantity and quality. First, there is no general agreement on what constitutes a unit of quantity or quality of education. Second, a single measure of educational output is probably not possible, as educators have many goals. Levin, in 1974, included as educational goals cognitive learning, inculcation of attitudes and values, and reproduction of the social relations of production (32). Thus, the output measures adopted in the size-economies literature are surrogates at best.

The number of students measured by enrollment or average daily attendance has been the most commonly used output measure (26, 42). Average daily attendance has been used as a surrogate for number of students educated, while enrollment has been taken as a proxy for size of school building (16).

Student number is a poor output surrogate, however, to the extent that education has public goods characteristics. The number of students also does not provide information on the quality of education, but, as most questions related to size are concerned with the potential cost savings associated with educating different numbers of pupils, it can serve as an adequate quantity measure.

Meaningful analysis requires education quality to be held constant in estimations using student number as an output proxy, although in practice this has not always been done. Achievement test scores are the output quality proxy generally used (53). However, ability to perform well on standardized tests is only one of many educational quality aspects and this is usually not closely related to additional education expenditures. Other quality factors must also be held constant in the estimation. Levin concludes: "...it is obvious that statistical estimates among existing schools that consider only the achievement score outcomes of students will not give us estimates of the production frontier..."(32).

An alternative approach has been to use inputs as surrogates for output quality (18). The input approach is advantageous because it avoids not only some of the output measurement problems but also the multidimensional nature of output quality. The key disadvantage is that reseachers do not fully understand the input/output relationship, so inputs may be a poor surrogate for output quality.

Test scores are another output surrogate which has been used as the sole output measure in the production function analyses (29, 33). However, test scores are a poor surrogate to the extent that schools are trying to produce outputs other than academic learning.

Welch, though not seeking.to examine size-economies in themselves, used his analysis of educational returns across 45 States to comment on potential economies (52). Expected gross return (income) was the output measure adopted and secondary school size the scale surrogate used to examine economies. The inherent weakness in this approach is that it assumes the only objective of education is to increase income-earning abilities.

Input Measures

Factor inputs (equations (5) and (7)) are necessary elements in both the production and average cost equation. Inputs should include the student inputs, native intelligence and effort, and the school inputs, labor and capital. One study also argues that the student's home environment should be considered as another input (53). Unfortunately, qualified data are frequently unavailable on most facets of the quantity and quality of these inputs, causing researchers to omit or inadequately account for them. Capital and student input data are most frequently ignored.

School-provided inputs have been measured either by expenditures or by explicit quantities or qualities of labor and capital inputs (29). One difficulty in using expenditures as a surrogate for all inputs is that production functions may vary according to the population density of the area served by a school and other factors. Less densely populated areas, for example, may have more capital in the form of smaller and more numerous buildings, a factor which can be substituted for transporting students greater distances. Therefore, expenditures which vary because of different production techniques do not necessarily signal any variation in output.

Production-function differences aside, if inputs were hired in order to minimize costs and relative input prices were the same in each location, expenditures would be an adequate input measure. However, inputs are unlikely to be hired so as to minimize costs. Also, relative input prices will vary according to such factors as union pressures and cost of living. Thus, school expenditures are likely to be a poor surrogate for actual inputs.

Labor inputs are included in most size-economies studies. Measures of the quantity of labor usually include the pupil-teacher ratio and number of auxiliary personnel (16, 54). Many studies have also used teacher quality measures, such as teacher salary (Hind), teacher education (Michelson), and teacher experience (Katzman) as proxies for labor quality (17, 34, 26).

A number of labor input proxies are significant factors in cost or production equations. Nonetheless, the relationship of labor inputs to educational output is not settled. Sher and Tompkins conclude, "educational research has failed to identify a single resource or practice which is consistently effective in bolstering achievements" (47).

Spreading capital costs over more units is often considered a major source of school economies. Therefore, to the extent that capital is an important input in educational production, it should be included in the average cost and production functions. Yet, one of the important data shortcomings of size-economies literature has been its general inattention to capital inputs. Most of the studies reviewed ignore capital, though two measures of capital (other than expenditures) are found in the studies: square feet of building space and building value (25, 4, 16, 55).

King and Wall illustrated the importance of capital by using engineering data to show that gymnasiums can be significant contributors to economies of size in high schools (30). The per pupil construction costs of gymnasiums were shown to fall by nearly 50 percent and per pupil yearly operating costs by more than 20 percent, as student populations increase from 400 to 2,200.

Failure to include capital in the regression equation (when it is important to educational output and costs), causes a specification error in the estimated equation, resulting in two problems. First, the regression coefficients on any variables correlated with capital inputs are biased. Second, the error variances are biased upwards, causing the test for significant size-economies to be too strict (25).

Students, as well as schools, are important elements in the educational production process. Student inputs refer to the education-related characteristics of students and their families that are incorporated into the educational process. Students contribute their initial academic ability, which has generally been IQ measured, along with their attitudes and willingness to work (36, 2). Family attitudes and encouragement are other student input factors (53).

Costs

Most school-level studies use current or instructional expenditures to determine average per pupil costs. The reasons are straightforward. Capital expenditures occur too infrequently to adequately measure actual yearly capital costs and data on depreciation or building value are sometimes not available.

A shortrun cost curve can be estimated if variable costs are the dependent variable and all important inputs are entered in the cost function (including level of capital inputs). Correctly specified cost functions (using current expenditures as a measure of variable costs) can be used to estimate shortrun average cost curves to the extent that current costs reflect variable costs. However, shortrun average cost curves fail to provide information on the optimal use of capital over time and on the economies associated with capital inputs.

Longrun average cost curves, however, require total costs (labor and capital) as the measure of costs and require labor and capital inputs as explanatory variables. Therefore, as none of the school-level regression studies explicitly included capital consumed in the cost measure, the estimates to date can be useful for evaluation of efficiency in the use of labor but not in the use of buildings and equipment.

The use of expenditure data as a cost proxy, which has been the common practice, has several difficulties. True costs, such as for buildings, are frequently unavailable and expenditures are infrequent, so this component is frequently omitted. Also, there may be expenditures for items which are not consumed in the study time period, so expenditures are likely to fluctuate around costs.

A serious difficulty can also result because expenditure levels are determined in a political arena. Therefore, the expenditure levels in a district, or between schools in the district, are not likely to be cost-minimizing or consistent across the district. Thus, an intradistrict analysis based on expenditures would be most susceptible to differences in expenditures based on political motivations. This problem can be overcome most effectively by estimating a cost curve which holds inputs and quality and quantity of output constant.

RESULTS OF SIZE-ECONOMIES RESEARCH

Per pupil school costs appear to be characterized by a U-shaped average cost curve. Katzman's studies were the only school-level research which showed evidence of diseconomies throughout the estimated range (26, 27). His cost curve analysis found a positive correlation between costs and capacity utilization which led him to conclude that either quality consistently rises with capacity utilization or diseconomies exist throughout the range. However, he obtained mixed results when examining educational production functions. Katzman, using the same data set in analysis of the size and capacity versus cost relationship, finds economies of size (27). So, Katzman's results do not point to a definitive result.

Certain school-level research concludes that some economies do exist (see table). Researchers, however, would not agree on the degree of economies because the measures of costs and size and the type of schools analyzed differ widely. Nonetheless, it may be noted that in each case where "optimum" (minimum cost) size schools are found to be relatively small, the analysis is based on small or rural schools (17, 38, 55). So, the size range analyzed is generally restricted. Also, the Hind and Katzman studies are of elementary schools where any economies are likely to be smaller (17, 26, 27).

Other research where "optimum" sizes were indicated is based on urban or mixed high school data (27). Each study employing urban or mixed data finds minimum per pupil costs for high schools to be in the 1,400 to 1,800 pupil range. The district-level study best able to provide information on school costs also found economies, although over a smaller range (16). Essentially all of the studies suggest that diseconomies will occur for large size schools, so the average cost curve remains U-shaped.

Wales took exception to the finding of a U-shaped average cost curve for teacher costs (51). He found significant coefficients for the equation by using a rectangular hyperbola form. However, by dividing the sample into five class sizes and estimating a cost/size relationship for each class, he demonstrated that costs decline at a decreasing rate. Wales claimed that the continuously declining average cost curve best reflects teacher costs until increased pupil-teacher ratios are not advantageous. At this point the cost curve becomes horizontal.

These studies, as already noted, usually ignore the costs associated with buildings. Yet the King and Wall study demonstrated that the construction and operating costs of school gymnasiums are a source of size-economies (30). Therefore, the school cost studies probably tend to understate the available economies.

Three district-level studies analyze administration costs individually. However, these administration costs may include some associated with the school, as well as with the district operation. Hirsch, Wales, and White and Tweeten all found economies associated with school district administration, although their studies examined only the relationship between the numbers of pupils and costs; the relationship between the number of schools and costs was not evaluated (19, 51, 53, 54).

The remaining district-level studies, all based on teacher, current, or total expenditures, have mixed results. Ordinarily, economies or constant returns are reported, although one study suggested decreasing returns as the size of the district increases (36).

School districts are composed of different mixes of primary and secondary students and schools and different size schools. Therefore, district-level studies of school expenditures are difficult to interpret unless all districts analyzed are unit (one school) districts, because economies will vary with the size and type of all district schools.

We find that size-economies are available at both the school and the district administration level, based on the studies which utilize appropriate units of analysis. This conclusion must be qualified, however. One qualification is that the interaction between school costs and district administrative costs has not been analyzed. Presumably, district costs are related not only to district size but also to the number of schools. Available economies may be reduced or increased by this interaction.

Second, the theoretical underpinnings of nearly all of the interpretable studies are deficient and some may suffer from data difficulties. As a result, though the direction of the results is clear, there are weaknesses in each study which raise doubts about the exact size of any economies.

Finally, questions arise regarding the impact of school size on the quality of education. James and Levin concluded, "Thus, all of the studies that have tried to relate school or school district size to education outcomes have found either no relationship or a negative one between student enrollments and the level of education outcome" (22).

They admit that there are questionable aspects of every study they considered, so the results are not conclusive. The studies usually find that quality (test scores) diminishes with increased quantity (student enrollments) when all resources are held constant, but this does not mean that quality declines with larger schools. Quantity and quality are the two components of output and they cannot be increased with fixed inputs unless they are complementary in production.

The relevant question for analysis is whether quality declines in larger schools when per pupil resources are held constant. Or alternatively, do the per pupil resources necessary to educate an additional student decline with school size when quality is held constant? A number of studies have tried to hold quality constant and economies were found (4, 42). Yet, the cognitive learning measure of quality used in these studies may not measure all types of quality. So, whether economies exist with quality held constant is still uncertain.

APPLICATION OF SIZE-ECONOMIES RESEARCH

The studies show that size-economies are available for schools and school districts. However, as the average cost curve appears to be U-shaped, diseconomies result for larger sizes.

The policy implications of this analysis rest on the issues to which these conclusions might be applied: (1) Should schools or school districts be consolidated? (2) What happens to education expenditures as populations grow or decline? and (3) What happens to costs if services are increased for the existing population? size-economies results, for the most part, are insufficient to answer these questions.

School or school district consolidation remains the most common problem to which size-economies research has been applied. However, size-economies research is insufficient to reveal all of the benefits and costs associated with consolidation. One reason is that the requirement of size-economies in the range of consolidated output is too strenuous a test for cost-savings derived from consolidation. For example, consolidations can be cost-saving even if a high-cost small school is consolidated with a lower cost school producing in a constant-cost range. However, knowledge of the educational cost curves provided by size-economies research is usually insufficient to determine the actual cost savings derived from consolidation (10).

Second, size-economies research presumes that other costs do not change with size, even though consolidation means that the geographic area from which students are drawn increases. A wider area served ordinarily increases transportation expenses (at least for the students and their parents). That other costs rise with size is not new; Cohn, for example, observed that higher related costs may prevent consolidations from being cost-saving (4).

The interaction between potentially lower school costs and the higher transportation costs entailed when students are placed in the most "efficient" size school has recently been investigated. Holland and Baritelle examined the least-cost pattern of allocating students across the nine school districts in Lincoln County, Washington (20). They concluded (because of the large transportation costs involved) that the savings from consolidation would be only approximately 1.3 percent of total costs, clearly not a major savings. They further argued that as no value had been placed on children's time, their estimate is an upper limit. This finding, using a case study approach, is probably applicable only to sparsely populated areas, as Lincoln County has a population density of 4.08 per square mile and fewer than 10,000 residents.

White and Tweeten have examined optimal school district size for various student densities (54). They found that the minimum cost-size district ranges from 300 pupils for a low-density district to 1,075 pupils for a high-density district. The findings suggest that the more sparsely populated areas are less likely to gain from consolidation than the more densely populated areas.

The least-cost size school may also depend upon whether new buildings will be constructed or whether students will be redistributed among existing schools. When school buildings are present, the potential operating cost-savings from redistributing students to more optimal size schools may be offset by the increased capital costs of building new schools or by increased transportation costs. If new schools are added or if there are alternatives for existing buildings, all of the costs are variable and a more optimal size facility can be constructed.

The impact of consolidation on quality of life and education must also be considered. Consolidation frequently means the elimination of some neighborhood schools and a loss of the school's community identity which may have adverse effects on community life (47). Also, the relationship between school size and educational quality has not been determined conclusively. The larger school can frequently offer a greater range of opportunity, while reducing each student's chance to participate. Research on this issue is likely to continue for some time.

Size-economies research must be used cautiously when determining what happens to education expenditures as populations grow or decline, because expenditures tend to respond to population shifts only after a time lag (11). Therefore, size-economies research probably understates the initial changes in per pupil expenditures which result when population grows in areas still able to obtain decreasing costs or when population declines in areas experiencing increasing costs.

Initial changes in per pupil expenditures are overstated in those (population growth) areas experiencing increasing costs, and in those areas with declining population who are experiencing decreasing costs. This is, however, only a short-term problem, as expenditures eventually adjust to the expected level.

Size-economies research is also inappropriate for explaining expenditure responses to population change because it deals only with the supply or cost side of the market. Population adjustments affect local income levels, as well as that group identified as the median voter. This means that demand for education (probably expressed as a different quality for the same quantity) is likely to increase or decrease, causing expenditure changes which would not be predicted by size-economies research.

Increasing services for existing populations would mean increasing a school's quality for a given number of pupils. Usually, size-economies research does not provide information on costs associated with increasing quality because economies are examined in terms of quantity.

White and Tweeten, who examined average cost curves for three different quality levels using type of courses offered as the quality surrogate, found that average cost curves vary with quality such that the minimum cost occurs at 550 pupils for the minimum program and at 900 pupils for the desirable program (54). If we accept their quality surrogate, average costs are observed to decline over a larger quantity range for high-quality rather than for low-quality education.

CONCLUSIONS

Certain economies do seem to be associated with large-scale education. The results must be considered separately, however, because the economies associated with secondary schools, primary schools, and school districts arise from different sources and must be evaluated with different units of analysis. The minimum high school cost-size appears to fall in the 1,400 to 1,800 pupil range in densely populated areas, although the optimal size varies with a number of cost factors, including population density.

Economies also appear in elementary schools, although over a much smaller pupil range. Again, the degree of economies varies with many things other than the size of the school. Finally, evidence supports the existence of economies in the provision of district-level administrative services. Savings can accrue from grouping more pupils under the same administrative district. These results indicate that small towns and less densely populated areas are likely to experience higher costs for providing the same quality of education than are medium size areas.

The extent and availability of size-economies in education is not a settled issue. Theoretical, methodological, and data problems qualify all the reported findings. Further work is necessary to resolve these issues, but the research will be repetitious and unproductive unless it deals with and overcomes certain problems.

New research should follow a theoretical framework using the behavioral relationships underlying the supply and demand aspects of education. Also, appropriate data sets, including information on capital and labor inputs and quality of inputs and outputs, must be available. And analysis of schools or school districts must be geared to the questions being asked. Usually, school data is better for examining the actual provision of education and school district data is better for evaluating overall administrative costs.

Size-economies results must be applied cautiously, and with full recognition of the unique characteristics of each place, because considerations other than our finding that size-economies exist are vital to determining the potential savings to be derived from size-economies.

The existing size of schools or school districts is also an important consideration. The school or district may already be at its low-cost size, or it may be too large or too small. However, many nonsize-related factors, such as breadth of curriculum, quality of education to be provided, and density of the student population, will affect the size and degree of economies.

Operating a relatively large school or school system is likely to be cost-saving when broad course offerings are made available, when populations are fairly dense, and when new capital expenditures are to be undertaken (the building of new schools). Other circumstances, such as low student population densities or substantial investment of capital are likely to yield less savings for larger schools or school districts.

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